

Amendments to the Specification

Paragraph at page 3, line 18 to page 4, line 1:

The density of the plasma adjacent the target 34 is increased by a small unbalanced nested magnetron 60 [[56]] placed in back of the target. Fu describes such a magnetron in U.S. Patent 6,183,614. It includes an inner pole 62 of one magnetic polarity surrounded by an annular outer pole 64 of the opposite polarity, both supported on and magnetically coupled by a magnetic yoke 66. Horizontal components of the magnetic field in front of the target 34 trap electrons and increase the plasma density and hence the sputtering rate. The small area of the magnetron 60 concentrates the target sputtering power in the area adjacent the magnetron 60, again increasing the plasma density. The magnetron 60 [[56]] may have various shapes including circular, oval, triangular, and racetrack. To provide uniform sputtering, the magnetron 60 is supported on and rotated about the central axis 32 by a rotary drive shaft 68. The total magnetic intensity of the outer pole 64, that is, the magnetic flux integrated across its face, is significantly greater than that of the inner pole 62 causing the magnetron 60 to be unbalanced. The ratio is at least 1.5 and preferably greater than 2.0. The unbalance causes magnetic components to project from the outer pole 64 towards the wafer 40, both confining the plasma and guiding any tantalum ions to the wafer 40.

Paragraph at page 4, line 25 to page 5, line 4:

When the coil 70 is negatively biased, it attracts the argon ions to sputter tantalum from the coil 70. When the coil 70 is driven by RF power it generates an axial RF magnetic field which induces an azimuthal electric field to induce a plasma region in the lower portion of the chamber 30. That is, the secondary plasma source creates a disk-shaped region of argon ions close to the wafer. Another RF power supply 78 is coupled through a capacitive coupling circuit 79 [[80]] to the pedestal electrode 38, which induces a negative DC self-bias at the edge of the adjacent plasma. As a result, the argon ions in the secondary plasma source, as well as any from the top

magnetron/target source, are accelerated to the wafer 40 and sputter etch it. Because of the anisotropy produced by the acceleration, the energetic ions reach to the bottom of the via holes and are effective at selectively etching the bottom portion 26 relative to the sidewall portion 22.

Paragraph at page 9, lines 10-27:

The magnet ring 90 is positioned outside the chamber sidewall 30 generally radially outwardly of the coil 70 to create a dipole ring magnetic field 92 that is largely axial (parallel to the central axis 32) adjacent and parallel to the faces of the coil 70. This axial portion on the inner coil face tends to trap plasma electrons, depending on their energy and velocity direction, and thereby creates a magnetic barrier significantly reducing the diffusion of plasma electrons to the coil 70 or the shields to be described later. The magnet ring 90 may be formed of multiple permanent magnets of the same polarity arrayed about the outer circumference of the chamber 30. Although generally the ring's magnetic polarity does not directly affect the desired barrier, it is preferred that the polarity of the ring 90 be opposite or anti-parallel that of the stronger outer pole 64 of the roof magnetron 60. A parallel orientation, on the other hand, would tend to draw the magnetic field 92 away from the inner coil face and towards the outer pole 64 of the adjacent roof magnetron 60, thus degrading the desired effects at one point of the coil 70. Ding et al. in the grandparent U.S. application 09/993,543, now published as US2003-089,601-A1 and issued as U.S. Patent 6,875,321, place a similar magnet ring in a similar position although a coil is lacking. However, they advocate the parallel polarity orientation of the magnet ring with the outer pole 64 of the roof magnetron 60 in order to further extend the projecting magnetic field from the outer pole 64 toward the wafer 40 to thus further guide any ions sputtered from the target.

Paragraph at page 10, lines 16-32:

Electromagnets can provide somewhat similar effects to the permanent magnet. As illustrated in cross section in FIG. 7, a solenoid coil 100, also called an electromagnet, is wrapped around the central axis 32 on the outside of the chamber wall 30 to act as a magnetic ring similar to the magnet ring 90 of FIG. 5. A DC current source 102 or other power supply powers the

solenoid 100 to produce a magnetic field 104 that is largely vertical on the inner face of the RF band coil 70 with a polarity inside the bore of the solenoid 100 that is preferably opposite that of the outer pole 64 of the roof ~~magnetron 60 magnet 64~~ of FIG. 5. Advantageously, the current source 102 is selective so that the intensity of the magnetic field can be varied, either to optimize the process or to vary the magnetic field between steps of a process. The solenoid 100 preferably has a length and position similar to those of the permanent magnet ring 90 of FIG. 5. The solenoid 100 may have a single turn or multiple turns and may be formed as an annular band as is the preferred RF coil 70. The single-turn implementation need not extend the full 360° extent of a circle, but an angular gap of 25°, preferably about 18°, may exist between the two ends of the coil 70 to allow isolated electrical connections to the two ends.

Paragraph at page 11, lines 22-26:

Another type of annular electromagnetic ring is an annular array of smaller axially oriented solenoids effectively individually replacing the permanent magnets of a magnet ring. Ding et al. have described this configuration in the grandparent application 09/993,543, now issued as U.S. Patent 6,875,321. Such a solenoid array may be azimuthally tuned if the solenoids are separately powered.

Paragraph at page 12, line 8-13:

A magnet ring 136 of the invention is partially fitted in and supported by a recess in the lower portion of the upper chamber wall 120. The magnet ring 136 may be formed of two 180° segments bolted together end to end to form a circular structuring capturing a large number of permanent magnets, for example twenty or more. The carriers are bolted to the chamber wall 120 by unillustrated mechanical structure. The general carrier and magnet design is disclosed by Ding et al. in the 09/993,543 patent application, now issued as U.S. Patent 6,875,321.

Three Paragraphs at page 12, lines 22 to page 13, line 21:

A band-shaped or tubular RF coil 160 with an aspect ratio of preferably at least four is supported on a single-piece inner shield 162 through five insulating standoffs 164 capturing outwardly extending tabs 166 of the coil 160. The RF coil 160 ^{[[162]]} should be positioned inside the metallic shields to prevent the shields from shorting out the RF fields. The shields, as long as they are made of non-magnetic materials, have insubstantial effect on the DC magnetic field from the ring magnet 136. The relative positions of the RF coil 160 and the magnet ring 136 have been previously discussed with reference to FIG. 5.

The inner shield 162 extends from a top end adjacent the target backing plate 130 to a bottom end below the RF coil 160 and typically to just below the upper surface of the pedestal 146 at its processing position. The inner shield 162 protects the chamber wall 120 from sputter deposition and is usually considered a consumable item that is replaced after a fixed number of deposition cycles so that the deposited material that has accumulated to a substantial thickness does not flake off and create particles. The top end of the inner shield 162 fits into the recess 132 formed by the target flange 128 and its corner with a small separation between it and the target flange 128 and the isolator ^{[[129]]} 126. The small gap acts as a plasma dark space which will not support a plasma, thereby preventing sputter deposition of metal in the gap and shorting of the target to the grounded shield 162 or the metal rim 122. An annular flange 168 extends radially outwardly from the inner shield 162 and is supported on and electrically grounded to an inner ledge of the upper chamber wall 120. The flange 168 is located between the upper and lower ends of the inner shield 162 to allow the upper end of the inner shield 162 to extend in front of both the rim 122 and the isolator 126. A separate rim 122 is preferred to allow screw fixing of the shields to the chamber wall 120. The inner surface of the inner shield 162 has a smooth contour beyond bead blasting with no surface deviating by more than 10° from vertical except for the rounded top and bottom tips. This smooth surface reduces flaking of material deposited at sharp corners.

The inner shield 162 is additionally illustrated in plan view in FIG. 10 and in orthographic view in FIG. 11. Five circular recesses 170 are formed on the outer wall of the shield 162 to accommodate an outer cap 172 together with screws passing through holes 174 allow the outer

cap 172 and an inner collar 176 to capture the coil tabs 166 through apertures 178 through the shield 162 in the area of the recesses 170, thus fixing the coil 160 [[170]] to the inner shield 162.